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IC CARD  
[IC kado]

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## Claims

1. A type of IC card characterized by the following facts:

the IC card has an intermediate sheet made of a plastic material,

cover films made of a plastic material and set on the inner/outer surfaces of the intermediate sheet,

and a semiconductor chip, which is set on one of said two cover films and is buried in said

intermediate sheet;

in this IC card, said intermediate sheet is formed from a thermoplastic plastic material, and said cover films on the outer/inner surfaces are formed from films having their orienting axes nearly in the same direction.

2. The IC card described in Claim 1 characterized by the fact that said cover films on the outer/inner surfaces have their orienting axes deviated from each other by  $8^{\circ}$  or less.

3. The IC card described in Claim 1 or 2 characterized by the fact that said cover films on the outer/inner surfaces are formed from a material with a low linear expansion coefficient of 50 ppm or less at temperature over the glass transition temperature.

4. The IC card described in any of Claims 1-3 characterized by the fact that the elastic coefficient of said intermediate sheet is double or more that of said cover films.

5. A type of IC card characterized by the following facts:

the IC card has an intermediate sheet made of a plastic material,

cover films made of a plastic material and set on the inner/outer surfaces of the intermediate sheet,

and a semiconductor chip, which is set on one of said two cover films and is buried in said

intermediate sheet;

in this IC card, said intermediate sheet is formed from a reactive hot melt.

6. The IC card described in any of Claims 1-5 characterized by the fact that said cover films on the outer/inner surfaces have nearly the same linear expansion coefficient.

7. The IC card described in any of Claims 1-6 characterized by the fact that the cover films on the outer/inner surfaces have nearly the same thickness.

#### Detailed explanation of the invention

[0001]

Technical field of the invention

The present invention pertains to a type of 3-layer structure IC card, which has cover films set on the outer/inner sides of an intermediate sheet having a semiconductor chip with the function of CPU, etc.

[0002]

Problems to be solved by the invention

The debit cards, credit cards, etc. now in wide use have a magnetic stripe coated on a plastic card, and the information recorded on the magnetic stripe can be read. For such magnetic recording type [card], a third party can easily decode the information, and the quantity of the information that can be recorded is small. This is undesired.

[0003]

In the recent years, people have developed IC cards with a semiconductor chip having the function of memory, CPU, etc. assembled on a card-shaped substrate. Such cards have been put in practical application. However, as the IC card is made thinner and thinner, depending on the properties of the

films applied on the outer/inner sides for improving appearance and protecting the substrate, the IC card may become warped or twisted, leading to deteriorated appearance. This is a problem to be addressed.

[0004]

In order to solve the aforementioned problem, in the prior art, people have adopted the following structure: a hole is drilled on a single plastic base plate (with thickness of about 0.5 mm), and a semiconductor chip is assembled in this hole. Then, on each of the outer/inner sides of the base plate, a plastic film with thickness of about 0.1 mm is bonded via an adhesive layer. With said structure, by adopting a hard plastic material as the base plate, it is possible to eliminate warp or twist as the properties of the films on the outer/inner sides have no influence. However, for the IC card with said structure, it is necessary to drill a hole on the base plate, and to coat adhesive on both outer/inner sides of the base plate followed by bonding the cover films. As a result, the number of steps of operation is increased, the mass productivity deteriorates, and the cost rises. This is undesired.

[0005]

The purpose of the present invention is to solve the aforementioned problems of the prior art by providing a type of IC card that has excellent mass productivity, is little affected by the properties of the cover films applied on the outer/inner sides, and can minimize the chance of warp or other deformation.

[0006]

Means for solving the problems

In order to realize the aforementioned purpose, according to the invention described in Claim 1, the intermediate sheet is formed from a thermoplastic plastic material, and the cover films on the outer/inner sides have their orienting axes nearly in the same direction.

[0007]

With said constitution, as the intermediate sheet is made of a thermoplastic plastic material, when heated, it melts, and adherence is developed. Here, the semiconductor chip is pre-installed on the cover film as one of the cover films of the outer/inner sides; the intermediate sheet is superimposed on said one cover film; and then the other cover film is superimposed. In this state, the assembly is heated while pressed, so that the semiconductor chip is buried in the intermediate sheet, and, at the same time, the cover films on the outer/inner surfaces are bonded to the intermediate sheet. Consequently, there is no need to pre-drill a hole for burying the semiconductor chip, and, there is no need to coat adhesive on the outer/inner sides of the intermediate sheet. As a result, the number of steps of operation can be reduced, and the mass productivity is thus improved.

[0008]

However, when the intermediate sheet is heated and melted so that its adherence is exploited to have the cover films bonded on the outer/inner sides to form the 3-layer structure, as shown in Figure 7, the phenomenon of warp caused by twisting of the IC card (hereinafter to be referred to as twist curling) takes place. The present inventors have found that the reason for said twist curling phenomenon is due to deviation between the orienting axes of the cover sheets on the outer/inner sides. That is, in the heating

process for bonding the cover films on the outer/inner sides of the intermediate sheet, the cover films extend. Then, in the next cooling process, the cover films shrink.

[0009]

Stretching of the cover films in company with said heating/cooling is especially significant in the direction along the orienting axis, that is, the direction of alignment (orientation) of the film molecules. Consequently, when there is a large deviation between the orienting axes of the cover films on the outer/inner surfaces, in said cooling process, as the cover films shrink, contracting forces act in direction/directions on the outer/inner sides, respectively, so that said twist curling takes place.

[0010]

According to the invention described in Claim 1 with said constitution, the cover films on the outer/inner sides are formed such that their orienting axes are nearly in the same direction. Consequently, it is possible to minimize twist curling of the IC card.

[0011]

In this case, according to the invention described in Claim 2, it is preferred that the deviation between the orienting axes of the cover films on the outer/inner surfaces be about  $8^{\circ}$  or less. As a result, even when twist curling takes place for the IC card, it is still possible suppress the deformation to smaller than twice the thickness of the IC card.

[0012]

According to the invention described in Claim 3, it is preferred that the cover films on the outer/inner surfaces be formed from a material with a low linear expansion coefficient of 50 ppm or less at temperature over the glass transition temperature.

[0013]

As the cover films are formed from said material with a low linear expansion coefficient, the stretching distance in company with heating/cooling becomes smaller. Consequently, even when twist curling takes place, it is possible to suppress its level.

[0014]

According to the invention described in Claim 4, the elastic coefficient of the intermediate sheet is double or more that of the cover films. As a result, the deformation caused by shrinkage of the cover films can be suppressed by the rigidity of the intermediate sheet, so that it is possible to suppress the level of the twist curling.

[0015]

According to the invention described in Claim 5, the intermediate sheet is formed from a reactive hot melt. The reactive hot melt is made of a thermosetting resin. It melts at a temperature lower than the glass transition temperature of the cover films, and it displays adherence. Usually, for a thermoplastic material, when the temperature rises through the glass transition temperature, the linear expansion coefficient rises. Now, as the intermediate sheet is made of a reactive hot melt, even when the cover films are not heated to the glass transition temperature, the intermediate sheet still can be melted.



Consequently, the stretching distance of the cover films becomes smaller, it is irrelevant to the deviation between the orienting axes of the cover films, and it is possible to minimize twist curling of the IC card.

[0016]

According to the invention described in Claim 6, the cover films on the outer/inner surfaces have nearly the same linear expansion coefficient. The invention described in Claim 7 is characterized by the fact that the cover films on the outer/inner surfaces have nearly the same thickness. With this constitution, the heating/cooling conditions of the cover sheets on the outer/inner sides become the same, and it is thus possible to suppress warp and twist of the IC card.

[0017]

Embodiments of the invention

In the following, an explanation will be given regarding an application example of the present invention with reference to Figures 1-6. First of all, as shown in Figures 1 and 2, IC card (1) has a 3-layer structure composed of intermediate sheet (2) that works as the intermediate adhesive layer, and cover sheets (3), (4) set on the outer/inner sides of said intermediate sheet (2).

[0018]

Said cover sheets (3), (4) on the outer/inner sides are sheets made of polyester base plastic material, or more specifically, PET (polyethylene terephthalate). Among said two cover sheets (3), (4), cover sheet (3) on the lower side as shown in the figure is taken as the circuit sheet. On one of its surfaces, coil-shaped circuit pattern (5) is formed as the conductor circuit is formed. At the same time,

semiconductor chip (6) connected to said circuit pattern (5) is assembled. Here, semiconductor chip (6) is buried in intermediate sheet (2), and it is protected by intermediate sheet (2).

[0019]

In this application example, said coil-shaped circuit pattern (5) is formed by printing an electroconductive paste, such as polyester base silver paste, by means of screen printing. Said semiconductor chip (6) is assembled as flip chip by means of, say, anisotropic electroconductive adhesive (7). This circuit pattern (5) works as an element that transmits/receives signals with an external equipment. In this application example, it works as an antenna for transmission/reception of electromagnetic signals. However, it may also have a constitution that allows reception of the power for operation of CPU or the like that has the circuit formed in semiconductor chip (6) by means of the electromagnetic signal from the external equipment received with said circuit pattern (5).

[0020]

Said intermediate sheet (2) is a sheet formed from a thermo-melting plastic material that has fluidity when heated and melted, such as polyester base hot melt adhesive. This intermediate sheet (2) protects circuit pattern (5) and semiconductor chip (6), etc., and, at the same time, it has the function of bonding with cover sheets (3), (4) itself. Consequently, it covers circuit pattern (5) and semiconductor chip (6), etc. without any gap. Also, cover sheets (3), (4) on the outer/inner sides not only protect intermediate sheet (2) that is relatively soft, but also have the function in improving the appearance of design of IC card (1) by applying printing of the design on them.

[0021]

As far as the thickness of intermediate sheet (2) and cover sheets (3), (4) are concerned, the thickness of intermediate sheet (2) that is the thickest among them is 0.3 mm, and cover sheets (3), (4) on the outer/inner sides have the same thickness of 0.1 mm. The overall thickness of IC card (1) is 0.5 mm.

[0022]

When IC card (1) with said 3-layer structure is manufactured, first of all, semiconductor chip (6) is assembled on one cover sheet (4). Then, intermediate sheet (2) and the other cover sheet (3) are superimposed sequentially on said one cover sheet (4) with semiconductor chip (6) assembled on it, and the entirety is heated and pressed by a hot pressing device not shown in the figure. As a result, the hot melt adhesive that forms intermediate sheet (2) is heated and melted to display certain degree of fluidity. The melted hot melt adhesive covers circuit pattern (5) and semiconductor chip (6) without any gap. At the same time, intermediate sheet (2) is formed with a uniform thickness as it is pressed from both upper/lower sides, and, due to its adherence, it is bonded with cover sheets (3), (4).

[0023]

During this heating process, the heating temperature is about 140°C, higher than the melting point of intermediate sheet (2). This temperature is also higher than the glass transition temperature of cover films (3), (4) (70-80°C). Then, by cooling, intermediate sheet (2) is solidified, so that a 3-layer structure IC card (1) composed of intermediate sheet (2) and cover sheets (3) and (4) on its outer and inner sides, respectively, is manufactured.

[0024]

In this way, as intermediate sheet (2) is formed from a hot melt adhesive, there is no need to form a hole for burying semiconductor chip (6) on intermediate sheet (2) beforehand. Also, when cover sheets (3), (4) are set on the outer/inner sides of intermediate sheet (2), there is no need to coat adhesive on the outer/inner sides of intermediate sheet (2). As a result, the number of steps of operation can be reduced, and the mass productivity is improved.

[0025]

As shown in Figure 5, said cover sheets (3), (4) are formed from film material (8) that was drawn in two orthogonal (longitudinal and lateral) directions (indicated by arrows A, B). For said film material (8), as it is drawn by prescribed rates in the longitudinal direction and lateral direction, respectively, the film molecules are aligned (oriented) in the synthetic direction of the longitudinal direction and lateral direction. The alignment direction of the film molecules is called orienting axis. As far as the direction of the orienting axis is concerned, as long as the position in the lateral direction (arrow B) of film material (8) is the same, it is nearly in the same direction at any position in the longitudinal direction (arrow A). Said biaxially drawn film material (8) usually is very wide (a few m in width), so that it is cut to width of about 50 cm and is then wound up as a roll.

[0026]

Figure 4 is a diagram illustrating the results of measurement of the direction of the orienting axis at various portions in the lateral direction of film material (8) with a width of 4 m. As shown in the figure, the abscissa represents the position in the lateral direction of film material (8), and the ordinate represents the direction of the orienting axis. Here, the position in the lateral direction of film material

(8) represents the distance from the center in the lateral direction of film material (8), with the value of 0 at the center of the lateral direction, and with the sign defined as plus (+) on the right hand side and minus (-) on the left hand side with respect to the central position. The direction of the orienting axis is represented by the angle formed with the straight line in the longitudinal direction (the length direction of film material (8)), with  $0^\circ$  representing the straight line along the longitudinal direction, and with the sign defined to be plus (+) for the angle in the clockwise direction from the straight line of  $0^\circ$ , and minus (-) for the angle in the counter-clockwise direction.

[0027]

As can be seen from Figure 4, the orienting axis of film material (8) is about  $25^\circ$  in the central portion, right end portion and left end portion [sic, in the central portion] in the lateral direction, and it is about  $80^\circ$  in the right end portion and left end portion. Thus, there is a significant difference. For the film materials cut to have a width of 50 cm from film material (8) and then wound up to rolls (hereinafter to be referred to as roll-shaped film materials) (9a)-(9h), [the difference in the orienting axis] for each same roll film material is  $5-6^\circ$  or smaller.

[0028]

In the present application example, for cover sheets (3), (4) on the outer/inner sides, they are cut from the same roll film material among said roll film materials (9a)-(9h), and they are set such that the inclination directions of the orienting axes are in the same direction. That is, when one cover sheet (4) has the outer surface of the roll film material as the side for bonding with intermediate sheet (2), the other cover sheet (3) has the inner surface of the roll film material as the side for bonding with intermediate sheet (2). On the contrary, when one cover sheet (4) has the inner surface of the roll film

material as the side for bonding with intermediate sheet (2), the other cover sheet (3) has the outer surface of the roll film material as the side for bonding with intermediate sheet (2). As a result, as shown in Figure 7, said cover sheets (3), (4) on the outer/inner sides have their directions of orienting axes (indicated by  $\theta$  in Figure 6) aligned nearly in the same direction, and the deviation between the orienting axes of two cover sheets (3), (4) is restricted to 5-6° or less.

[0029]

Figure 3 is a diagram illustrating the results of measurement of the quantity of twist curling of IC card (1) when the deviation between the orienting axes of cover sheets (3), (4) is changed to various values. Here, experiences suggest that whether the appearance of IC card (1) depends on whether the maximum height of IC card (1) is over twice its thickness as IC card (1) is set on a flat plane. The twist curling quantity is represented by the height dimension from the flat plane to the highest portion of the upper surface of IC card (1) as IC card (1) is set on the flat plane.

[0030]

As shown in Figure 3, when the deviation between the orienting axes of cover sheets (3), (4) on the outer/inner sides is 8° or smaller, the maximum twist curling is about 1 mm, and it is about twice the thickness (0.5 mm) of IC card (1), so that the deformation does not degrade the appearance. However, when the deviation between the orienting axes of cover sheets (3), (4) on the outer/inner sides is about 10°, the maximum twist curling of the IC card becomes about 2 mm, and the appearance degrades.

[0031]

From the aforementioned experimental results, one can see that in order to prevent the twist curling, it is preferred that the deviation between the orienting axes of cover sheets (3), (4) on the outer/inner sides be suppressed to  $8^\circ$  or less. In this application example, the deviation between the orienting axes of cover sheets (3), (4) on the outer/inner sides is restricted to  $5-6^\circ$  or less, so that it is possible to suppress the twist curling to less than twice the thickness of IC card (1), and there is no degradation in the appearance.

[0032]

Especially, in the present application example, as cover sheets (3), (4) on the outer/inner sides are formed from the same roll film material, said cover sheets (3), (4) have the same linear expansion coefficient and the same thickness. As they have the same linear expansion coefficient, two cover sheets (3), (4) have similar stretching distance, and it is possible to minimize warp of IC card (1) caused by a significant difference in the stretching distance between the cover films on the two sides. Also, as two cover sheets (3), (4) have the same thickness, the shrinking forces applied on intermediate sheet (2) due to shrinking of cover sheets (3), (4) are the same for the outer/inner sides of intermediate sheet (2), and it is possible to minimize the warp of IC card (1) caused by the difference in the stretching forces applied on cover sheets (3), (4) on the outer/inner sides.

[0033]

The present invention is not limited to the aforementioned application example illustrated with figures. It also allows the following modifications or expansions. That is, cover sheets (3), (4) on the outer/inner sides may be made of different materials or have different thicknesses. The elastic

coefficient of intermediate sheet (2) is preferably twice or more that of cover sheets (3), (4). As a result, as intermediate sheet (2) has a high strength against bending, it is possible to minimize the warp when intermediate sheet (2) receives shrinking forces acting on the outer/inner sides due to shrinking of cover sheets (3), (4).

[0034]

Usually, as the temperature rises across the glass transition temperature, the linear expansion coefficient of the plastic material rises drastically. The heating temperature for bonding cover sheets (3), (4) on intermediate sheet (2) is usually higher than the glass transition temperature of cover sheets (3), (4). On the other hand, the twist curling quantity of IC card (1) depends on the magnitude of the stretching distance of cover sheets (3), (4). Consequently, in order to suppress twist curling, it is preferred that cover sheets (3), (4) be made of a plastic material with a low linear expansion coefficient even when the temperature is over the glass transition temperature. More specifically, cover sheets (3), (4) may be made of a plastic material with a low linear expansion coefficient of 50 ppm even at the temperature over the glass transition temperature.

[0035]

Said intermediate sheet (2) may also be made of a reactive hot melt. The reactive hot melt is made of a thermosetting resin, and it can be melted to display adherence at a temperature (say, 60°C) lower than the glass transition temperature (70-80°C) of cover sheets (3), (4). Consequently, as intermediate sheet (2) is formed from the reactive hot melt, even when not heated to the glass transition temperature of cover sheets (3), (4), intermediate sheet (2) still can be melted so that it can be bonded to cover sheets (3), (4). Consequently, at a temperature lower than the glass transition temperature at which the linear



expansion coefficient of cover sheets (3), (4) is low, cover sheets (3), (4) can be bonded on the outer/inner sides of intermediate sheet (2). As the stretching distance of cover sheets (3), (4) in this case is small, it is possible to minimize the twist curling of IC card (1), and it is irrelevant to the deviation between the orienting axes of cover sheets (3), (4).

#### Brief explanation of figures

Figure 1 is a cross-sectional view illustrating the IC card in an application example of the present invention.

Figure 2 is an exploded oblique view illustrating the IC card.

Figure 3 is a diagram illustrating measurement. It shows the relationship between the deviation between the orienting axes of the cover films on the outer/inner surfaces and the twist curling.

Figure 4 is a diagram illustrating measurement of the inclination of the orienting axes of the various portions of the biaxially drawn film material.

Figure 5 is an oblique view of the biaxially drawn film material.

Figure 6 is an oblique view illustrating the direction of the orienting axes of the two cover films on the outer/inner surfaces.

Figure 7 is an oblique view illustrating the twist curling.

#### Brief explanation of part numbers

- 1 IC card
- 2 Intermediate sheet
- 3, 4 Cover sheet
- 6 Semiconductor chip

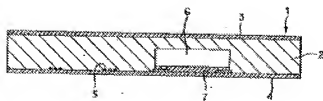


Figure 1

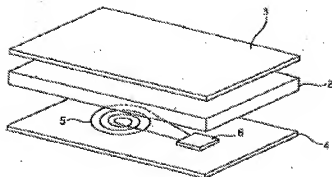


Figure 2

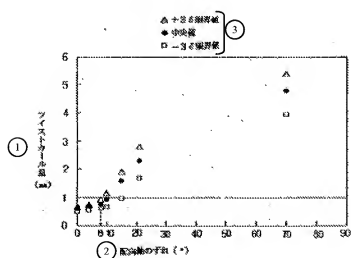


Figure 3

- Key: 1 Twist curling quantity  
 2 Deviation between orienting axes  
 3  $+3\delta$  limit value  
 Central value  
 $-3\delta$  limit value

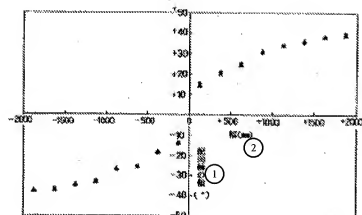


Figure 4

- Key: 1 Inclination of orienting axis  
 2 Width (mm)

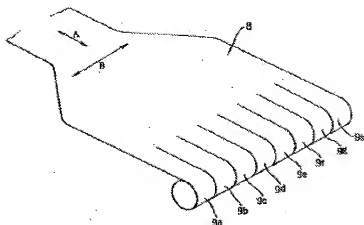


Figure 5

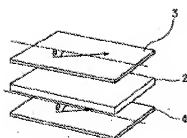


Figure 6

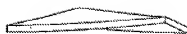


Figure 7